

***Troglocyclocheilus khammouanensis*, a new genus and species of cave fish from the Khammouan karst, Laos (Teleostei: Cyprinidae)**

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***Troglocyclocheilus khammouanensis*, a new genus and species of cave fish from the Khammouan karst, Laos (Teleostei: Cyprinidae).** - *Troglocyclocheilus khammouanensis*, new genus, new species, is distinguished by the absence of externally visible eyes, the presence of several rows of sensory papillae on the head, the shape of the mouth, lips and rostral fold, the slender and smooth last simple dorsal ray, and the lateral line scales with a notch on the posterior margin. Other southeast and east Asian cave cyprinids are discussed. The sensory function of the 'parietal processes' or 'parietal organs' of some species of *Sinocyclocheilus* (and its synonym *Gibbibarbus*) is doubted and an hydrodynamic function is hypothesized instead. The publication dates and authorship of *S. hyalinus*, *Protocobitis* and *P. typhlops* are discussed and lectotypes are designated for *S. hyalinus* and *P. typhlops*. *Barbus speleops* from Tham Phu Khieo, Thailand, belongs to the genus *Poropuntius* (nov. comb.).

Key-words: *Troglocyclocheilus* - cave fishes - taxonomy - *Sinocyclocheilus* - *Protocobitis*.

INTRODUCTION

Little information is available in the literature on Laotian fishes and by the end of 1995 only some 220 species were recorded in the scientific literature. Surveys conducted in 1996 and 1997 have increased this figure to about 360 and the total fish fauna of the country is expected to be around 500 species. Most of the earlier ichthyological activity focussed on the Mekong mainstream and there is little information on the Mekong tributaries. A significant exception is the just published survey of the Nam Theun and Xe Bangfai basins (KOTTELAT 1998). These basins include and are bordered by several limestone formations; lack of time, equipment and appropriate experience precluded their inclusion in the survey, although their potential as fish habitat was obvious.



FIG. 1

Map of the Khammouan karst northeast of Thakhek. Stippled: hills (corresponds approximately to area above 200-250 masl). 1. Tham Khoun Dôn; 2. Tham Houay Sai (resurgence); 3. Ban Phôndou; 4. Tham Kagnung; 5. Tham Houay Sai (sink).

Karst formations are widely distributed throughout Laos (FROMAGET 1927). The Khammouan karst (northeast of Thakhek, in Khammouan Province) is the most extensive one and has been the subject of most of the speleological investigations conducted in the country, even if these investigations are still quite limited (MOURET & VACQUIÉ 1993; BESSON *et al.*, sous presse; MOURET 1999). The Khammouane karst is made mainly of dolomites and dolomitic limestones dating to the late Palaeozoic (Devonian, Carboniferous, Permian). The summits of the hill ranges which make up this area have an average altitude of 600-800 m; the area seems to present a great number of swallow holes (pits perched on summits), most of them of very difficult access as a result of the very dissected tower-karst morphology. See MOURET *et al.* (1997: 6) for a geological map. Sinks and resurgences are numerous at the foot of the hills, and complete crossing from sinks to resurgences are common. These phenomenon have already been described in the earliest topographic surveys of Laos. CUPET (1900: 183) reports crossing the estimated 3 km [in fact 7.5 km] Nam Hin Boun tunnel in a canoe; he also mentions the underground course of the Xe Bangfai (p. 191). These two tunnels and others have been explored by Macey in March 1905 (MACEY 1908) and more recently between 1994 and 1997 (MOURET *et al.* 1994, 1996, 1997) (for aerial photographs of the entrance and resurgence, see KOTTELAT 1998: fig. 2a-c). Some of these tunnels are still the normal way to access some villages located in the interior of the karstic area (e.g. Ban Na polje). Noteworthy is that the succession of three tunnels on the lower Nam Kading reported by MACEY and which he estimated to represent about 7 km of subterranean river course, do not appear on the recent 1:100000 topographical maps.

The resurgence of the Nam Dôn is located at the southwestern edge of the Khammouan karst, near Ban Phôndou (Fig. 1). The resurgence itself ends after a few meters at a sump (a flooded passage) but a cave a couple meters away (Tham Khoun Dôn) is connected with the resurgence and allowed the exploration of more than 3 km of passages. Tham Khoun Dôn and the nearby Tham Houay Sai resurgences are the assumed resurgences of the waters of the Ban Vieng polje on the northeast, probably exiting the polje mainly through the Tham Kagnung and Tham Houay Sai sinks (note, a sink and a resurgence have the same name, but are distinct cavities; see Fig. 1). The distance between the sinks and the resurgences is about 7 km. This system has been studied in 1996-97 by a French team (mainly C. Mouret, F. Brouquisse and J.-F. Vacquié) who has surveyed about 8 km of passages. Cave divers (F. Auber, F. Bréhier, A. Espinasse, D. Sablé) explored the Nam Dôn resurgence itself in February 1998 for about 270 m. Blind cave fishes were found 150 m from the entrance, at a depth of 23 m.

This paper reports the discovery of the first cave fish from this formation and from Laotian waters. Future exploration will undoubtedly result in the discovery of several more species in the extensive limestone formations of the country.

MATERIAL AND METHODS

Methods for counts and measurements follow KOTTELAT (1984a, 1990). Toponymy and spelling follows the 1983 1:100,000 E48-90 Lao P. D. R. topographic map, on which Figure 1 is based. Co-ordinates were obtained from these maps. Abbre-

viations used are: NRM, Swedish Museum of Natural History, Stockholm; CMK, collection of first author; SL, standard length. Vertebrae are divided into preanal and caudal vertebrae; caudal vertebrae are those whose haemal spine is posterior to the anteriormost anal-fin pterygiophore.

Troglocyclocheilus n. gen.

Type species. *Troglocyclocheilus khammouanensis*, new species.

DIAGNOSIS. *Troglocyclocheilus* is distinguished from all genera of cyprinid fishes known from southeast Asia by the combination of the following characters: absence of externally visible eyes; several rows of sensory papillae on lateral and dorsal sides of head; mouth horse-shoe shaped, with thin and smooth lips, post-labial groove interrupted medially; articulation of lower jaw salient and in contact with its homolog of the other side of body (Fig. 2); last simple dorsal ray slender and smooth; posterior margin of lateral line scales with a notch (Fig. 3).

ETYMOLOGY. From the Greek trogle, hole, and *Cyclocheilus*, a generic name proposed for cyprinid fishes with which this genus is supposedly related (a name erroneously considered preoccupied and subsequently replaced by *Cyclocheilichthys*). Gender masculine.

Troglocyclocheilus khammouanensis n. sp.

Figs 2-4

HOLOTYPE. NRM 42535, 40.3 mm SL; Laos: Khammouan Prov.: Khoung Nam Dôn, resurgence of Nam Dôn [stream] near Ban Phôndou [village]; 17°33'50"N 104°52'20"E; F. Bréhier, 24 February 1998.

DIAGNOSIS. See generic diagnosis.

DESCRIPTION. General appearance is shown in Figure 4. Morphometric data of holotype, in percents of SL: total length 131.8; head length 31.0; predorsal length 51.6; prepelvic length 52.6; preanal length 73.7; head depth 15.9; body depth 18.9; depth of caudal peduncle 11.7; length of caudal peduncle 16.9; body width 13.9; length of dorsal-fin base 24.8; depth of anal fin 21.3; length of pelvic fin 17.4; length of pectoral fin 19.1; length of upper caudal-fin lobe 24.8; length of median caudal rays 14.1; length of lower caudal-fin lobe 32.3.

Fins not very well preserved and most membranes damaged. Dorsal fin with 4 simple and 8 branched rays, last one split to the base; last simple ray slender and not serrated posteriorly; distal edge concave. Pectoral fin pointed or falcate, with 1 simple and 14 branched rays. Pelvic fin pointed, with 1 simple and 8 branched rays; axillary scale present but not conspicuously different from or larger than other scales; origin at vertical of 2nd branched dorsal ray and 13th lateral line scale. Anus separated from anal-fin origin by 2 or 3 irregularly set scales. Anal with 3 simple and 5 branched rays, last one split to the base; distal edge concave. Caudal fin forked, with 10+9 principal rays, 9+8 being branched; 9 upper rudimentary rays and 8 lower.

Body entirely scaled, scales in predorsal area and on belly conspicuously smaller than on flank and organised in somewhat irregular rows. 36+2 scales along lateral line, about 20 predorsal scales, $1/25/1/8\frac{1}{2}$ scales in transverse line, $1/24/1/3\frac{1}{2}$ scales in transverse line on caudal peduncle, 4 scales between lateral line and pelvic origin. Lateral line pore at the apex of a notch along posterior margin of scale. Lateral line canals simple. No scale sheath at anal- and dorsal-fin base. Apparently, several rows of sensory papillae on dorsal and lateral sides of head, and possibly on skin folds on throat (due to the fixation, rows of papillae are poorly preserved; the approximate position and organisation of those tentatively recognised is shown in Fig. 2).

No tubercles on snout. Mouth horse-shoe shaped, with slender and continuous lips. Postlabial groove interrupted medially. Deep rostral groove. Rostral fold with a median part and a large lateral fold on each side of jaw. Two pairs of small barbels, one in the rostral groove immediately in front of corner of mouth, one (very slender) immediately in front of lateral part of rostral fold. Symphysal knob on lower jaw. Articulation of lower jaw salient and adjacent to its homolog of the other half of body. 4+14 outer gill-rakers on right anterior gill arch. Pharyngeal teeth 5,3,2; all but one teeth were no longer attached to bone when examined; the formula is based on teeth sockets and the number of teeth recovered in the connecting tissues.

Vertebrae: 21 preanal + 14 caudal.

ETYMOLOGY. Named for the Khammouan limestone formation.

HABITAT AND FIELD OBSERVATIONS. FB observed 4 or 5 fish all about the size of the holotype while diving, about 150 m from the entrance of the Nam Dôn resurgence and under 23 m of water. The fish were immediately above the substrate (blocks and clay). They were swimming about 50 cm above the bottom, hiding near the bottom when disturbed; they were moving swiftly, but only for short distances, about 50-100 cm. A second dive was organised in order to catch them. It was late and time was only available to catch a single specimen. The next day the team was due to move to another area and it was not possible to obtain additional specimens. The species has not been seen in any other siphons (turbid water, too great distance from bottom, etc.). Shrimps were also present; they apparently have normally developed eyes.

Troglocyclocheilus khammouanensis is apparently known to the local fishermen who report catching it in their nets in July when floods flush them from the cave(s). They reportedly call it "paa kham khong" ("fish which crosses the streams"). Villagers in Ban Thonglôm (18°00'40"N 104°24'50"E) and Ban Khen (18°04'20"N 104°27'10"E) also report occasionally collecting blind cave fishes in the Nam Hinboun during the wet season; this may refer to the present species and/or other species. The presence of other hypogean species is expected in this area.

In an adjacent resurgence of the same system (Tham Houay Sai, also near Ban Phôndou, 17°33'40"N 104°52'50"E), J. Lordon collected *Chela laubuca* (Hamilton, 1822) in a lake about 800 m from the cave entrance (CMK 14418).

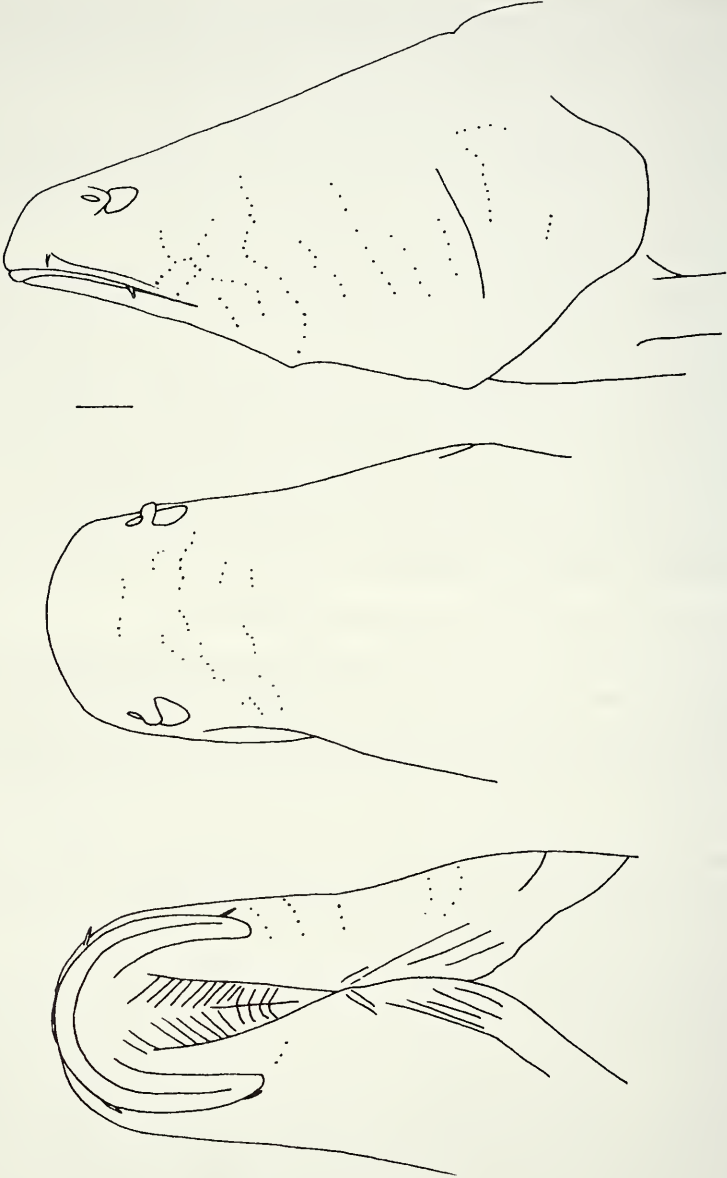


FIG. 2

Troglodyclocheilus khammouanensis, NRM 42535, 40.3 mm SL. Head in dorsal, lateral and ventral view, showing approximate position of rows of papillae. Scale bar 1 mm.

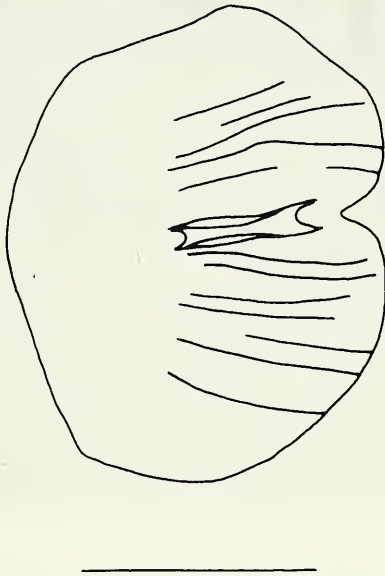


FIG. 3

Troglocyclocheilus khammouanensis, NRM 42535, 40.3 mm SL; lateral line scale, right side, under dorsal-fin origin. Scale bar 1 mm.

DISCUSSION

A phylogenetic analysis of the Cyprinidae is not yet available and with a single available specimen which cannot be dissected and the scarcity of both data and phylogenetic hypotheses supported by data, it is obviously premature to further discuss the relationships of *Troglocyclocheilus*.

Troglocyclocheilus shares a number of characters with *Cyclocheilichthys*: rows of sensory papillae on head; mouth horse-shoe shaped, with thin and smooth lips, post-labial groove interrupted medially; articulation of lower jaw salient and adjacent to its homolog of the other side of body; rostral fold with a median part and a large lateral fold on each side of jaw; one slender barbel (not always present in *Cyclocheilichthys*) immediately in front of lateral rostral fold and one in the rostral groove immediately in front of corner of corner of mouth.

Beside the absence of externally visible eyes, *Troglocyclocheilus* is distinguished from *Cyclocheilichthys* in having the last simple dorsal ray slender and smooth (vs. bony and serrated posteriorly), a more slender body (body depth 18.9 % SL, vs. 25-46; SONTIRAT 1976: table 12), absence of anal and dorsal-fin sheath scales (vs. presence), scales on predorsal area and belly smaller than those on flank and organised

in somewhat irregular rows (vs. not conspicuously distinct from those on the flank), posterior margin of lateral line scales with a notch (vs. rounded or slightly concave), and head papillae organised in a few irregular and widely set rows (vs. regular and very closely set rows). Most or possibly all these character states could possibly be considered as adaptations to the cave environment, but there is no reason, with the available data, to assume that *Troglocyclocheilus* is derived from a *Cyclocheilichthys* ancestor (which would mean that *T. khammouanensis* should be treated as a species of *Cyclocheilichthys*). There is no reason to support this hypothesis rather than another. The main diagnostic character of *Cyclocheilichthys* is the presence of numerous closely-set rows of papillae on almost the whole surface of the head. In *Troglocyclocheilus*, the pattern of the rows of papillae is much less complex, the individual papillae are larger and the rows more widely spaced. A reversal of the complexity of the sensory papillae from the state observed in *Cyclocheilichthys* to that of *Troglocyclocheilus* would seem surprising in a cave environment as, on the contrary, one would expect that a complex sensory papillae pattern could be an advantage for a blind cave fish. The advantages (if any) of having a notched lateral line scales is unknown, but it is tempting to imagine that somehow this affects the efficiency of the lateral line system, which again would be a clear advantage for a blind cave fish. Therefore, we prefer to hypothesize that while *Troglocyclocheilus* is possibly related to *Cyclocheilichthys*, its immediate relationships are not with *Cyclocheilichthys* but with some other lineage. Cephalic sensory papillae apparently appeared in several cyprinid lineages, or they secondarily disappeared in several lineages; in several genera they are known only in juveniles (see below). With some 30 taxa new to science out of 162 collected in a one month survey in the surface waters in the immediate vicinity of the type locality (KOTTELAT 1998) and with the total documented Laotian fish fauna rising from about 220 to 360 between March 1996 and June 1997 (KOTTELAT, unpublished), the potential to discover an extant epigean ancestor to *Troglocyclocheilus* is still real.

Rows of sensory papillae are known in adults of a few genera of southeast Asian cyprinids. They are easier to observe in formalin fixed specimens; in alcohol fixed specimens (like the holotype of *T. khammouanensis*), it is more difficult to observe and describe them with accuracy. In *Cyclocheilichthys* and *Neobarynotus*, most of the head is covered by very closely set and regular rows of papillae while in *Troglocyclocheilus* the rows are irregular and widely spaced. In juveniles of *C. repasson* about 40 mm SL, the rows of papillae are less numerous and the space between them is wider than in adults; it is possible that in larger specimens of *Troglocyclocheilus* the number of rows of papillae could increase too. In *Eirmotus* and *Oreichthys* there are only a few rows of papillae, but these genera are distinguished in having fewer scales in lateral row (19-23, vs. 36+2 in *Troglocyclocheilus*), an incomplete lateral line (vs. complete). In addition, *Eirmotus* has a serrated last simple dorsal ray (vs. smooth) and *Oreichthys* has (at least in large individuals of some populations) a vertical row of up to 5 pores on the anterior scales of the flank (vs. absence).

Although missing in adults, rows of papillae are present in juveniles of *Tor* and *Neolissochilus* and probably in several other genera (juvenile material of many genera

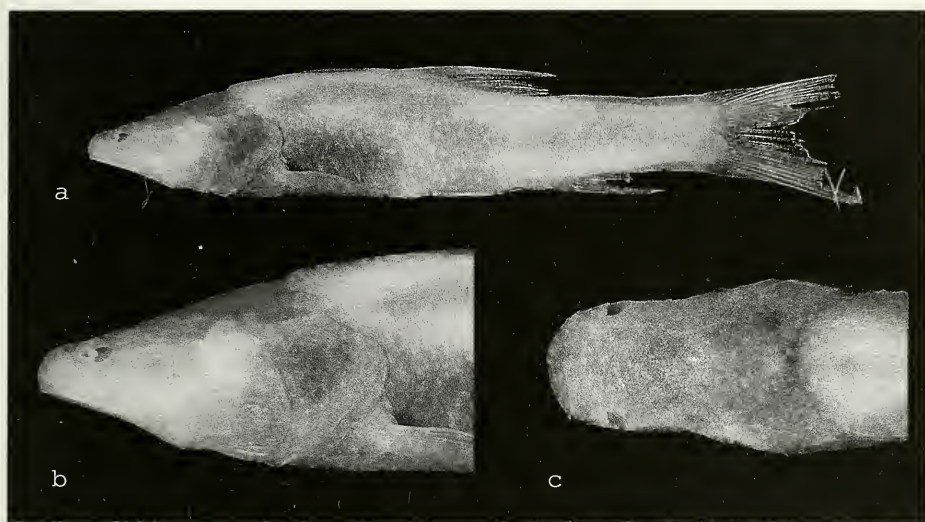


FIG. 4

Troglodyclocheilus khammouanensis, NRM 42535, holotype, 40.3 mm SL.



FIG. 5

Laos: Khammouan Prov.: Khoung Nam Dôn, resurgence of Nam Dôn near Ban Phôngdou; 24 February 1998 (Photograph by André Espinasse).

is not available to check this character). *Tor* and *Neolissochilus* share with *Troglocyclocheilus* the smooth last simple dorsal ray, but are easily distinguished by the shape, position and structure of the lips (fleshy and often with median lobes, vs. thin and without lobe), snout (fleshy and usually projecting, vs. not projecting), rostral fold (without, vs. with lateral folds), and scales (large scales, less than 30 in lateral line in most species, lateral line scales not notched, vs. smaller scales, 36+2 in lateral line, lateral line scales with a notch along posterior margin). Rows of sensory papillae are also known in South Asian and African cyprinids.

Rows of papillae have also been reported in *Sinocyclocheilus* Fang, 1936 a genus known only from the Yangtze basin in China. The genus is of interest as it includes a number of hypogean species (see brief synopsis in CHEN & YANG 1993) but the sensory papillae are neither mentioned in the English text of the original description nor shown on the figures of the hypogean species: *S. angularis* Zheng & Wang, 1990, *S. microphthalmus* Li, 1989, *S. hyalinus* Chen & Yang, 1993, *S. anatirostris* Lin & Luo, 1986 and *S. anophthalmus* Chen & Chu (in CHEN *et al.* 1988) and it is not known whether they are effectively missing. *Gibbibarbus cyphotergus* Dai, 1988 is apparently a species of *Sinocyclocheilus*; the original description mentions and figures the sensory pores, but does not mention how this genus would differ from the very similar looking *Sinocyclocheilus*.

(A note on nomenclature: The original description of *S. hyalinus* is usually given as authored by Chen & Yang, in CHEN *et al.* 1994. In fact, the name is already mentioned in CHEN & YANG [1993], accompanied by a list of characters, especially in Table 2. This satisfies the conditions of arts. 10-13 of the International Code of Zoological Nomenclature and makes the name available from CHEN & YANG [1993: 123]. Similarly, the names *Protocobitis* and *P. typhlops* are available from YANG & CHEN [1993: 125] in the same volume and not from YANG *et al.* [1994: 92, 93]. CHEN & YANG [1993] did not designate a holotype for *S. hyalinus*, so that all specimens used for their account are syntypes; they did not list the specimens used, but this account is derived from the CHEN *et al.* [1994] description, thus the specimens listed in CHEN *et al.* [1994] as holotype and paratypes are syntypes. Specimen KIZ [Kunming Institute of Zoology] 916001 cannot be holotype as the holotype should be designated in the original description. In order to ensure stability, KIZ 916001 is here designated as lectotype of *S. hyalinus*. The same reasoning applies to *P. typhlops* which is available from the YANG & CHEN [1993] account in which 7 specimens are listed but none designated as holotypes. Thus these 7 specimens are syntypes and, KIZ 9180001, listed as holotype by YANG *et al.* [1994], has no holotype status. KIZ 9180001 is here designated as lectotype).

Sinocyclocheilus is distinguished from *Troglocyclocheilus* in having more scales along lateral line (61-84 [some cave species are naked], vs. 36+2), lateral line scales with an entire margin (vs. notched), and an osseous and serrated last simple dorsal ray (vs. slender and smooth). *Troglocyclocheilus* has a small dorsal hump immediately behind the head, and, if the holotype were a juvenile, this hump could be much more conspicuous in larger specimens, possibly paralleling the development

observed in some *Sinocyclocheilus*. Such humps are known in a variety of cypriniforms, e.g. *Gila cypha* and *Xyrauchen texanus* from the Colorado River; several *Puntius* of Mindanao (see HERRE 1924: pls. 1-2; WOODS 1968) and seem to have an hydrodynamic function and to be an adaptation to fast flowing waters. MILLER (1946: 415) commented that "the action of the current against the prominent nape tends to force the fish down toward the bottom or the sides, where the flow is not so torrential as in midwater".

Several species of *Sinocyclocheilus* have what Chinese authors (ZHENG & WANG 1990; CHEN & YANG 1993) have called "parietal process", "parietal projection" or "parietal organ". LIN & LUO (1986: 381) report "frontal processes". CHEN & YANG noted that "the more specialized the species, the more developed the parietal projection, and by contrast the more reduced the other sense organs" and concluded that the "parietal projections" have a sensory function. This hypothesis suffers from serious shortcomings: it has not been demonstrated that the projections are homologous in all species; it has not been unambiguously demonstrated that the projections are processes of the parietal bones; and there is no histological data to indicate a sensory function. As these projections are always associated with a conspicuous dorsal hump, we hypothesize that, as the hump, they have an hydrodynamic function. Another evolutive advantage of the hump and projections could be to prevent the fish from entering too small cavities into which they might become wedged.

Projections in similar position are also observed in other (epigeal) fishes, like the acanthurid genus *Naso* La Cèpède, 1802 and males of the family Kurtidae. The function is not known in *Naso* (in one species the projections are known only in males), but in Kurtidae the process is used to hold the eggs.

Poropuntius speleops (Roberts, 1991) nov. comb.

A single other species of hypogean cyprinid has been described from mainland southeast Asia, *Barbus speleops* Roberts, 1991. The generic position of this species has not been addressed in the original description, the author flatly stating "[the species'] phyletic relationships to surface dwelling forms is unknown, and therefore it is assigned arbitrarily to the barbine type genus *Barbus*". *Barbus*, as presently understood, being restricted to Europe, North Africa and southwestern Asia, this decision is hardly understandable. ROBERTS (1991: 107) reported that some tubules of the lateral line have one or two short ventero-posteriorly directed branches, a character diagnostic for *Poropuntius* and some species of *Cyclocheilichthys* (*C. enoplos*, *C. furcatus*; see SONTIRAT 1976) and *Cosmochilus* (*C. harmandi*; see DURAND 1940: 10, pl. 3; KOTTELAT 1984b: 799, fig. 2). The absence of cephalic sensory papillae and the head morphology exclude inclusion of *B. speleops* in *Cyclocheilichthys*; the absence of papillae on lips and the overall appearance exclude inclusion in *Cosmochilus*. ROBERTS (1991) also reports the presence of melanopores which are probable vestiges of upper and lower marginal stripes on the caudal fin. Such stripes are present in several genera of cyprinids, but they are especially conspicuous and diagnostic in *Poropuntius*, *Hampala* and in some species of *Barbodes* and *Garra*. All but *Poropuntius* have simple

(unbranched) lateral line tubules. The absence of the adhesive disc excludes inclusion of *B. speleops* in *Garra*; the overall appearance, especially the slender body, excludes inclusion in *Barbodes*; and the small mouth (not reaching vertical of front margin of eye) and the overall appearance exclude inclusion in *Hampala*. None of the characters listed by ROBERTS disagrees with what is presently known of *Poropuntius* species and we consider *B. speleops* as a species of *Poropuntius*. Apparently, a single species of *Poropuntius* is presently recorded from the Mae Nam Mun basin (in which Tham Phu Khieo, the type locality of *P. speleops* is located), and this species is identified as *P. laoensis* (see KOTTELAT 1998: 48, for diagnosis and illustration). Several other species of *Poropuntius* have been collected in the Mekong basin in Laos and one may expect that more than one species occur (occured) in the Mae Nam Mun basin.

The title of the original description of *P. speleops* explicitly describes the fish as blind, but the eyes are present (although apparently vestigial in adults) and no information is provided which could permit to comment on the functionality of the eyes. It seems thus inappropriate or premature to describe this fish as blind (unable to see).

ACKNOWLEDGMENTS

We are pleased to thank the other members of the Expédition Spéléo-Plongée Laos 98, Franck Auber, André Espinasse, and Denis Sablé, for their help in the field; the Fédération Française d'Etudes et de Sports Sous-Marins for sponsoring the expedition; Jérôme Lordon and Louis Deharveng for making available the specimens collected in Tham Houay Sai; Graham Proudlove for providing copies of some of the Chinese literature; Sven Kullander and Fang Fang for commenting on the manuscript and preparing x-rays of the specimen; and the numerous Laotian citizens who helped in various ways in the field, especially Vannivong Soumpholphakday (Sodetour).

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